DOCUMENT RESUME

ED 061 040 SE 013 233

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TITLE	A Study in Student Attitude Change Resulting from Non-Sequential Curriculum Modification Measured by Semantic Differential.
PUB DATE	Aug 71
NOTE	100p.; M.A. Degree Thesis, University of Texas, El Paso
EDRS PRICE	MF-$0.65 HC-$3.29
DESCRIPTORS	Attitudes; *Elementary School Science; Evaluation; *Instruction; Masters Theses; *Science Course Improvement Project; *Student Attitudes
IDENTIFIERS	*Science A Process Approach

ABSTRACT

The results of semantic differential scores lead to the conclusion that there was no significant change in student attitudes when transferred from a concept approach in science to the process-oriented method of Science--A Process Approach. (CP)

A STUDY IN STUDENT ATTITUDE CHANGE RESULTING FROM NON-SEQUENTIAL CURRICULUM MODIFICATION MEASURED BY SEMANTIC DIFFERENTIAL

A Thesis

Presented to

The Faculty of the Graduate School

The University of Texas at El Paso

In Partial Fulfillment

of the Requirements for the Degree

Master of Arts

submitted by

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August 1971

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ACKNOWLEDGEMENTS

I would like to express my gratitude to Dr. James L. Milson for the time, the supervision and the scholarly advice he has provided as director of this research. I am also deeply grateful to my family for their assistance, their encouragement and their patience.

THESIS STATEMENT

This research is a measure of student attitude change upon non-sequential introduction of the process-oriented method, Science--A Process Approach, into the science curriculum.

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CHAPTER I

INTRODUCTION

The quest for knowledge and truth seems innate in the nature of Man, for through the ages scholars have been in pursuit of them. The task of scientist has been to seek these truths through observations, to gather data, and test hypothesis. In that same spirit of quest, searching for ways students can participate in the excitement of a scientific adventure is a challenging and rewarding undertaking for any educator. (4:vii)

The importance science can play in the development of a child's rational thinking has not generally been accepted until recently. It has been found that intellectual stimulation during the formative years of the child is as important as inborn ability. Science is related to this intellectual development to the extent curriculum design incorporates the direct experiences of his physical world. (34:19) Curriculum organization should emphasize strategies of inquiry and of critical thinking. Equally important to this development is the nature of the activity as it correlates with the physiological maturation of the child. (40:61)

If intelligence is born of action, the objectives of developing mental processes of science can be achieved only when students are actively engaged in investigation of

relevant topics. (34:83) Science--A Process Approach is among the first of the new elementary programs designed for developing mental processes through the procedure of inquiry. (48:413) It just might be that involvement in such a quest would generate positive attitudes toward the activity.

Studies conducted at Harvard University in 1959 by Gardner and Lambert indicated that there is a positive correlation between knowledge gained and the attitudes that a student projects towards a subject. These same studies suggested that students who are given the opportunity to actively participate in and to express themselves freely in the learning process show greater interest in the learning than those who are merely passive recipients. (14:7)

STATEMENT OF PURPOSE

The purpose of this study is to investigate the effect of non-sequential insertion of the highly structured, activity-centered, process-oriented Science--A Process Approach on the student's attitudes toward his science class at the fifth grade level.

THE NEED FOR THIS STUDY

Discussions of the merits of the various methods by which one generation transmits accumulated knowledge did not originate with the present era. It probably dates farther

back than the years comprising the Athenian Democracy. Although there are no verifiable records, it is likely that the members of the earliest familial societies were concerned with effective ways of teaching their offspring the necessities for survival. Each civilization, each age since the dawn of Greek civilization has had its peculiar problems which challenged existing teachings. The Greek civilization under a new form of democratic government, was challenged to teach the young men to become an effective orator, one who could alter the path of the nation through verbal persuasion. Young men sought training that would enable them to gain an eloquence in speaking by acquiring masterful techniques of verbal persuasion. And even as it is true today, not all teachers in ancient Greece agreed on effective ways to meet the needs of training young men. (36:138)

Socrates and Isocrates were the two leading examples of the divergent means employed toward attainment of the goal of becoming effective speakers. According to Good, Socrates engaged men in dialogues and conversations, guided them to the statement of definition, cultivated a frame of mind through continued guidance and even provocations, led them to many definitions and redefinitions of life and its values. (24:23) The atmosphere of evaluation and re-examination of definitions was conducive to the solutions of problems. Socrates' method appeared superficially to be informal and dependent

upon the immediate situation for structure and to the solution of a problem. (36:138)

On the other hand, Isocrates trained students to use prepared speeches and arguments already tested in public. He inculcated proven practices which became his students' tools to participate in Greek public life. In our era, there seems to be innumerable approaches to teaching, but upon a close examination of the various methods, each represents a modification of the methods used by Socrates or Isocrates. (36:140)

Fundamentally, the contrasting methods either employ the active participation of students in the development of an inquiring mind or the indoctrination of accepted knowledge and practices. The appropriateness of either method should be based upon the needs and problems stemming from the existing society. (36:140)

Ours is a technical space age in which science and society were probably never so intimately bound up with one another. Economic and technical development of all classes of people in society are reflected by science. Communication, television and news media have increased man's knowledge immeasurably. Travel has widened his experiences and has facilitated contacts with distant places and peoples. The shift of the nation's position in international power influences our educational goals significantly. (27:109)

The challenge of today is to combine dynamic scientific knowledge, humane democratic ideals and the demands on the individual that a polyfaceted culture exerts. And as previously stated, objectives of any discipline are significant only when those objectives are congruent with the goals of society. (36:140) These elements always increase the pressures for effective science instruction in the elementary school. The question then arises of which knowledge and of how much will be relevant. (33:30)

If the assumption that direct experiences play a more significant role in children's learning ability is valid, then there is a need to determine if one method is superior to another in attempts to improve their concept development, their problem-solving ability, their interest, and their scientific behavior.

There is a need to try out curricula that include active involvement by students in the learning process. However, care must be taken to assure that field testing of curriculum materials is valid. An improperly designed testing may result in negative attitudes which will affect the results.

Many administrators and educators in the El Paso Public School System feel that, to be consistent with the demands of our times, students must have the flexibility and the proficiency to cope with a diversified society in transition.

Science--A Process Approach is a program based on long-range achievement of process goals constructed in a sequential, ordered progression ideally introduced at Level A (kindergarten) with the addition of a level each subsequent year.

However, in order to expedite the program, in some of the pilot schools higher levels were introduced to students who had not had experience with the program; and in one particular center all levels of the program were introduced simultaneously. There is a need for studies that explore into the value and validity of this procedure as a way of introducing new programs into curriculum and the effect it may have on student attitude, which will in turn effect their achievement.

THE SCOPE AND LIMITATIONS OF THE STUDY

The content and application of this study are limited in scope since research materials and facts consists primarily of survey of published information related to this study and the results and evaluations are from the research centers of the American Association for the Advancement of Science program, Science--A Process Approach.

Data from an original survey conducted by the writer on fifth grade classes from three El Paso Public Schools will be included. Science--A Process Approach will be compared to the program of Concepts of Science. And the results of

Semantic Differential scores will be evaluated. The size of the sample and the difficulty of obtaining an acceptable research design further limit the generalizability of this study.

Some intellectual processes are not quantifiable and must be measured in terms of behavorial objectives. Evaluation which measures skill sometimes indicates practice in desired behavior. (34:98) Measurement is one of man's most powerful tools, but the difficulty consistently lies in the fact that the unmeasured and the unmeasurable aspects of process often appear more valuable than those which can be or have been measured. (23:127)

The results of the competency measures of this study may not adequately evaluate student achievement as all levels of the program were initiated simultaneously into the El Paso Schools this year. Students in Level E, for example, have not had the preceding basic skills necessary for the successful acquisition of integrated skills.

THE DEFINITIONS OF TERMS

There is a difference between the study of science and the study of other disciplines. The true essence of science is that quest which lies between the physical world that science departs from and the unknown that science enters into, the illusive, the intangible, theoretical aspects of a world

which consists of mainly empty spaces, of electrons that travel randomly at unbelievable speeds, of molecules from which the stuff of life is made, and of its miraculous return again in the form of technology or of medical progress. To relate this abstract world whose intangible components have no apparent relevance to man's everyday thinking is a challenge which confronts any classroom science teacher. (34:25)

The numerous privately and federally funded teaching programs all seek new directions for science education. These programs list a wide variety of objectives, but when categorized each fall into those objectives that pertain to the factual structure of science or that pertain to the development of the processes of science. (27:109)

The structure of science refers to the fundamental concepts and principles that underly the discipline. On the other hand, the processes of science imply the intellectual operations or the behavior of the scientist as he explores and seeks solution to his problems. (49:53)

Around these two central philosophies emerged new curricula for the teaching of science. The <u>content-centered approach</u> usually presents predetermined, isolated facts about science and content is centered around a textbook; which is the opinion of one or at the most, a few persons.

The <u>conceptual approach</u> strives for the acquisition of content and principle through appropriate sequential

organization of facts into a broad activity scheme designed to lead to the understanding of the basic concepts of science. (27:110)

The process approach incorporates content and the development of mental skills of inquiry, discovery, and problem-solving.

The Semantic Differential is an instrument that subjects meaning to a quantitative measure; when used as a technique of measurement, it can be an index of meaning. (39:26) This index of meaning is further subjected to factor analysis in order to isolate and identify the major factors operating within it. The three factors extracted for this study are: the evaluative factor which is a measure of judgment or of value; the potency factor, associated with size, weight, and strength and is indicative of power and force; and the activity factor, indicative of motion and mobility, associated with sharpness and abruptness. (39:38)

In order to allow for a quantitative determination, the term significant change for the purposes of this study will be defined as statistical significance at the 0.05 level.

For better understanding and for clarification of meaning for this study, the terminology used herein will be applied in the context as defined.

THE STATEMENT OF HYPOTHESES

For the purpose of the testing the effect of non-sequential insertion into the process approach three null hypotheses will be tested. These hypotheses are as follows:

There will be no significant change in the evaluative factor score of the Semantic Differential when the student is transferred from a conceptual approach curriculum to a process approach curriculum.

There will be no significant change in the potency factor score of the Semantic Differential when the student is transferred from a conceptual approach curriculum to a process approach curriculum.

There will be no significant change in the activity factor score of the Semantic Differential when the student is transferred from a conceptual approach curriculum to a process approach curriculum.

CHAPTER II

REVIEW OF RELATED LITERATURE

THE BACKGROUND AND HISTORICAL SETTING OF ELEMENTARY SCHOOL SCIENCE

Science instructions in the early days of America were not unlike the methods prevalent in Europe. Between the years 1700-1850 teaching of science consisted of examining, naming and discussing nature objects such as rocks, plants, animals and constellations; and it was essentially a natural history program. This popular method required very little teacher training. The objects examined were limited only to those which were readily available in the immediate environment. The major educational goal was the collection of interesting specimens, and the accumulation of information regarding nature objects was often unrelated to any concepts and laws; knowledge was limited to that which was acquired through the individual's native senses. (48:7)

In the 1850s, another educational trend influenced science teaching. The Pestalozzian Object Teaching, a technique widespread in Europe was also introduced in America. In spite of the common origin of the study of nature, the English and American versions of "object study" did not follow the original trend. An adaptation that became

best known was designed in Oswego, New Jersey, and became known as the "Oswego Method". This methodology of object teaching did not effectively contribute to a sense of sequence or direction nor did it stress the primary purpose of science instruction which was the study of nature in the environment of the child. (48:34) Content was fragmented by the lack of continuity in the organization of the material. The objectives were the superficial descriptions of physical objects.

Religious and moral instruction of the child became the goals for education between the years 1850 and 1900. (48:8) Science books and nature stories adapted well for the purposes of teaching moral values and of developing desirable human qualities. Descriptive connotations were assigned to animals and plants; for example: "the wise old owl," "the sly fox" or stories of Br'er Rabbit.

Following the period of teaching science for the training of moral values, the educational objectives became the "strengthening of the mental faculties by exercise and the application of the mind to make it more fit." Elementary science sought to exercise the child's memory and to increase his power of observation. (48:8) Science activities consisted of memorization and classification of nature objects. Assuming that the young child had limited capabilities of reasoning in the interpretation of daily natural occurances,

the educators believed that strengthening of the mind through memorization and categorization of concrete objects would eventually lead the child to perform the more sophisticated functions of the mind. (29:22)

Around 1900, a Swiss scientist, Lewis Aggasiz, after twenty years experience as a lecturing professor at Harvard University, felt the need for a more practical approach to learning science. He organized a small laboratory in a barn and initiated the nature study movement. The aims of his nature study movement were to develop an active interest for the material things in the environment and to cultivate the ability of discernment through observations of differences and similarities of various specimens of plants and of animals.

Within a decade this movement received the support of the leading educators of the period. Wilbur J. Jakeman known as the father of nature study, was a great advocate. He published books which greatly influenced the popularity of the movement. (48:37) The method, calculated to develop scientific interest in a child, proposed to develop a kind of scientific mind that would observe and investigate nature with an intellectual integrity.

It became evident by 1920 that a new design in the curriculum for science study was needed. The nature study movement which was developed by men, although well-intentioned, lacked the broad perception of the possibilities of

science and lacked the understanding of the learning processes of the child. About this time, William James, John Dewey, and others were having tremendous impact on the philosophy of education and science instruction. (48:37) An important contribution to educational trends of this period was John Dewey's contention that methodology was of equal importance or even greater significance than actual accumulated knowledge. In other words, "how" a discipline is mastered is more important than "what" is learned.

In 1927 a course of study designed for a science curriculum at the Horace Mann Elementary School by Gerald Craig of Columbia University had far-reaching influence on the development of science curriculum. (19:2) Craig worked to organize scientific conceptions and objectives that would guide children toward becoming a whole person. Craig was aware of more than the cognitive domain of science instruction; he also emphasized the affective aspects of attitude, interest and appreciation of the values of life as they are related to the world around the child. He was responsible for the revision of subsequent teachers' manuals, curriculum study guides and textbooks to include the cognitive as well as the affective domains as objectives of any curriculum. (19:3)

About 1930 a reaction arose against the traditional education and attempts were made to emphasize individuality and the kind of intellectual and emotional growth that would

flourish in a free permissive environment. (43:23) The Progressive Schools were established in California and in New York state at this time and were very popular. Children were given few restrictions and few limitations. As more insight and understanding of the internal process of learning were gained, however, educators and parents felt that more control was needed over the child's behavior and over his education in knowledge of fundamental subjects. The values of the society were not being transmitted to the young generation. (43:23)

In an attempt to give more direction to the learning experiences of the child, the Guidance Movement was initiated and became accepted. The teacher and those responsible for the education of the child would analyze conditions which might prove conducive to the learning situation in the classroom. Favorable atmosphere and simulated situations would be created to involve the learner in the thinking processes and in the learning activities. The teacher no longer served as director or programmer. (43:24)

Between the years of 1940 and 1950 very little science was taught as an activity-centered discipline. Science textbooks served as readers to teach reading. As a counter approach, the next decade, the 1960s took the form of experimentation. Science teaching had degenerated to teaching isolated and often inaccurate facts and consequently was not

included in many school programs. Scientists felt schools were not effectively imparting the knowledge or the attitude necessary for students to be literate enough to understand scientific advances in a technical age. The rapid dynamic changes in our society and the "knowledge explosion" made many science courses of study obsolete even before they were published. A search for a more meaningful direction for science education became an urgent need. (19:4)

In 1962, the Commission on Science Education of the American Association for the Advancement of Science explored new approaches for teaching science to children. School administrators, consultants, teachers, child psychologists and scientists combined their efforts to develop programs in science education that might contribute to the total education of the child. (19:6)

Research centers of universities throughout the country became focal points for innovations of new programs and resultant contributions are evidenced in such curricula as the University of California Elementary School Science Program, The University of Illinois Inquiry Development Program, School Science Inquiry Study at the University of California at Berkeley, Elementary School Science funded by The National Science Foundation, and Science--A Process Approach endorsed by the American Association for the Advancement of Science and many other excellent programs developed to meet a specific

philosophy and a need.

EVOLVING PHILOSOPHIES OF SCIENCE TEACHING

Traditionally, we have been concerned with shaping the child to fit the demands of society. The expectations of each individual in a relatively stable society were determined before his birth and the function of educational institutions would be that of preparing each child to fill an expected slot. The goals of education remain that of preparing the individual to become a participating and contributing member of a society. In the structure of a stable society, these institutions function to build into the child predetermined theories, beliefs, and conclusions which are internalized by the child in order to evoke certain emotional responses and fixed sets of standard performances. (43:23) The responses of the child would indicate results of successful teachings. He did not have to generate his own inferences, his own responses or his own conclusions.

In 1910, the Central Association of Science and Mathematics Teachers published a report on the fundamentals of science teachings which stressed the development of problem-solving as the major teaching objective. (36:148) It further stated that this approach is more congruent with the aims of education in the twentieth century. The objectives of any discipline are significant only when those

objectives are consistent with the aims of education in general. (7:6) That which is taught should have some bearing on world problems, social relevance and personal significance to the student.

The challenge of education is greater in our changing world in which institutions and values are threatened, in which stability is an evasive factor. The amount of knowledge is monumental and, yet we are rapidly accumulating more. It becomes increasingly difficult to select that which would be most relevant to the individual for his contemporary society. (23:127)

The impact of education is not seen in the content of a discipline but in the mental activity that the student with the aid of the teacher brings to bear on it. Interpretation of science facts or any school subjects have no distinct purpose except as accumulation of specific knowledge needed for a specific occupational goal or as knowledge or treasure of "culture heritage." (44:172)

Since it is not given to any of us to know what the demands of a future society will be upon the individual, it would seem imperative to develop men and women of integrity and imagination to be able to mold a life in accordance to their insight and to their vision. (23:127)

THE OBJECTIVES OF ELEMENTARY SCHOOL SCIENCE EDUCATION

The chief purposes of education in the United States is to help children acquire those understandings, attitudes and skills which happy and useful citizens of a democratic society need. If science education contributes in a significant way to realize this overall objective, then the inclusion of science in the elementary school is justified. Gerald Craig, in his pioneer 1927 work on the organization of science curriculum, set out to validate the criteria for selecting objectives directed towards helping boys and girls to meet and to solve intelligently the challenges of living. (19:2) His three criteria were: (1) the importance of selecting the concepts which would activate thought processes, (2) the emphasis on developing attitudes, knowledges and skills as a requisite for individual and social awareness, and (3) the importance of basic science knowledge to enable the individual to understand how to interpret the natural occurrences in his environment. These criteria have challenged and influenced the organization of the elementary school science program. (48:62)

The year the Russians launched Sputnik, 1957, was a crucial year for the total school science program. Educators and scientists re-examined the objectives, methods and

curriculum in the public schools. Surveys of various approaches to teaching science were conducted. Research funded by private organizations and by the Federal government to stimulate and to seek better ways to awaken young potential scientists were studied. (19:2) The long-standing controversy between the teaching methods of content and skills remained polarized in their respective camps.

A recent study of Ernest D. Riggsby found that in contemporary school science textbooks, descriptions confirm a widespread notion that there exists a variety of methods rather than one scientific method, and that processes of science are not always delineated and structured. (19:4)

Former emphasis upon basic principles of content is being re-examined and structure of science is being explored by Morris H. Shamos. He feels science instruction has failed to produce a science-literate group of students because the acquisition of the understanding of concepts is placed subsidiary to methodology. (19:4)

Currently, studies in inquiry training in which students systematically gather data about a problem, formulate hypothesis, and test the hypothesis through actual experimentations, are being conducted and refined by Richard J. Suchman. Considerable interest has been shown in his efforts by The American Association for the Advancement of Science, to give new directions to science programs. (19:5)

There is already evidence that pupils are interested in and are able to comprehend science content and science concepts. And further, it has been ascertained that with specific appropriate instructional materials the characteristic spirit of inquiry also could be instilled. Science--A Process Approach sponsored by the American Association for the Advancement of Science is such an approach. Useful science content is introduced as the children concomitantly acquire concepts and process experiences. (19:5)

Generally speaking, modern science curriculum states objectives that emphasize structure, process and attitudes.

THE NATURE OF SCIENCE

> Knowledge for the sake of knowledge, as the history of science proves, is an aim with an irresistible fascination for mankind, and which needs no defense. The mere fact that science does, to a great extent, gratify our intellectual curiosity, is sufficient reason for its existence . . . To the majority of laymen, science is valuable for its practical application. But to all the greatest men of science, practical application has emerged incidently as a kind of by-product. (46:2)

Science is an adventure of the human spirit, essentially an artistic enterprise based largely on faith in the orderliness, rationality, and beauty of the universe. Science is an intellectual search served largely by disciplined imaginations, involving inquiry, rational thought, and generalization. (18:6) The challenge that scientists face is an attempt to discover, to interpret, and to order the

vast storehouse of facts and principles of our universe. (19:6)

Science is a process of man's mind by which he seeks to reorganize nature and to learn from it. From the massive compilation of knowledge and facts he seeks to recognize an underlying principle or law through which he can systemize a wealth of information. These broad principles or laws can be called "concepts" or more preferably termed "constructs." Concepts enable scientists to reduce the volume of information into systemized manageable sequence for practical purposes. These concepts are intellectual tools which are used to interpret phenomenon of nature and to provide bases for solving new problems. (18:6)

An important aspect of science is the technique of science, the procedure used to observe, to order, to generalize, to comprehend, and to predict the environment. These are sometimes referred to as process or inquiry skills. Knowledge acquired, rather than knowledge found, is closer to the true nature of science. In the pursuit of truths, a scientist displays qualities of objectivity, skepticism, and impartiality.

Ours is an age of pragmatism; technicians and engineers often use their knowledge to develop a device or technique that may enhance our living conditions or alleviate human sufferings. This we call the technology of science or the

products of science. (18:6)

The technology of science has released man's energies and time that were once needed for maintaining survival. Now they may be used to further his knowledge of the universe and to increase the benefits to mankind. No aspects of life are untouched by the forces of technology nor unaffected by scientific development. Yet, curiously enough, the technology of science has seldom been the stimulus for scientific research. Inherent in man is the desire to explore the unknown and to reach out into the vast frontiers still closed to him.

A SURVEY OF THE NEW ELEMENTARY SCHOOL SCIENCE PROGRAM

Curriculum developers for the future will be a new breed of people consisting of first-rate scientists who are experts on subject matter, child psychologists whose designated assignments will be analyzing optimum conditions that promote learning, and media experts whose important task will be creating instructional materials, combining their know-how and experience to produce effective science programs. (18:25) In addition to meeting the educational goals, the curriculum builders must be aware of the effective domain as well as the cognitive domains of learning. Science and scientists have been accused of neglecting human values as

one of their goals. The reason may be due to the nature and to the complexity of the discipline, but also to the fact that society values education for diverse reasons. Education often serves as a means to attainment of power, position and material wealth. It is the belief of John Goodlad of University of California at Los Angeles, that either by design or by accident some of our present educational goals are not attainable by all segments of our society, and our marking or evaluating practices have drastic psychological consequences for that segment of society who can never aspire to meet the minimum standards of performances. (18:26)

It is also not realistic, however, to teach children that goals are achieved with ease and directness, as obstacles and difficulties are sure to be encountered. Throughout the school years, the child has been conditioned to the fact that failure is a disgrace. This attitude has stifled many potential creative thinkers and hampered initiative. Failure should be analyzed and redirected into a learning process. (47:522) Corneliu J. Troast also questions the attitude of some teachings that "anything goes." He believes that although the philosophy of new programs bases its theories on discovery and inquiry, it also has the obligation to correct hypothesis or concepts erroneously constructed by students. He believes that basic facts and truths should

be adhered to in science. (47:526)

New science programs that make adjustments to or have a built-in success system may have gratifying and revolutionary results. Programs can point out to children that learning has its own rewards--rewards which can bring a richer, fuller outlook that make living in a democracy a more appealing kind of life. Programs can be developed to help the child become a contributing member of a society in which he can find a measure of satisfaction by being able to solve his problems of life. (18:26)

It is the hope of many educators and scientists that the process approach for teaching any discipline will serve to meet these ends. Innovations begin at the secondary science level, filter through to the junior high schools, and finally reach into the elementary grades. As one views the many new programs being used, it is evident that the underlying philosophy, methods of operation, the suggested types of materials and the stress of process reflect the large-scale involvement of scientists and psychologists in the formative phases of the programs. Two major contributions to the successes of the programs are the availability of sufficient amounts of funds from the Federal government and also adequate support by private research institutions. (48:411)

There are some who criticize the new directions of

science. David P. Ausubel believes that the inquiry approach lacks breadth in structure, and probes too deeply in the narrow and limited areas merely for the sake of developing process skills. He believes that science literacy and learning the structure in sequential order should be the ultimate goal. Ausubel also believes that some activity skills are more appropriate when students have attained a certain degree of sophistication. Others feel that some programs are so highly structured they do not allow for individual differences nor for teacher creativity. Also, as yet, some evaluations are based on teacher testimonials and student enthusiasm. A true measure of achievement has not yet been devised other than specific evaluation of behavioral objectives. (48:411) Hopefully, these factors can be modified or corrected as the programs are continuously evaluated and revised.

The major experimental projects, their philosophy and curriculum materials are described in the following pages.

Science Curriculum Improvement Study

The wide acceptance of the Physical Science Study Commission's physics program and other successful secondary curricular reforms broke the barrier between universities and high schools. This was a tremendous boost to the elementary science program for receiving the needed financial support for any research study.

The Science Curriculum Improvement Study, funded by The National Science Foundation, was implemented at the University of California at Berkeley in 1961. (33:20)

The present content of science is a product of long, tedious process that man has abstracted from observation of natural phenomenon over the centuries. During the formative years, the elementary child engages in precisely the same type of observing and abstracting process with respect to his own environment. *Science Curriculum Improvement Study* (SCIS) has as its major purpose the development of scientific literacy within a meaningful conceptual framework by organizing significant content of science under a broad conceptual design. The curriculum developers take into account the developmental progression of the child, recognizing that there are optimal stages for specific learning skills that correlate with the maturation of the child. (29:20) The two underlying ideas of the program are the recognition of emerging qualitative stages of the intellectual capacity from childhood to adulthood, and the significant role environment contributes in the transition from one stage to the next as the child interacts with it. (29:20)

The various stages of intellectual development, as defined by SCIS, are roughly divided into four stages: the preoperational stage begins at about two years of age; the stage of formal operations, between the ages of ten and

fifteen; and only in the last stage are children able to reason as adults. (29:20) The results of these studies were the work of the Swiss psychologist Jean Piaget, and later elaborated by American scholars Jerome Bruner, Celia Stendler and others. The range of successive stages vary from author to author; however, in the development of individual teaching units, the conceptual framework of content are correlated to the four stages of child development. (18:33)

The four levels of abstractions are somewhat related in sequence to the stages of child development as viewed by Jean Piaget. Level I corresponds to the transition from the preoperational stage to concrete operational thought and serves as an introductory unit that prepares and precedes Level II. Level II units are based on physical sciences, life sciences and stresses quantitative comparisons. It is adapted to concrete operational level. Level III is a transitional stage between concrete thought and the formal operational stage in which the quantitative treatment is integrated with the previous levels of concrete learning to discover the interdependence of variables, such as temperature, rates of change, rates of growth in a biological phenomenon, or to describe interrelationships of physical life sciences through studies of living organisms or through investigations of energy transfers. Level IV requires

considerable proficiency of advanced mental interrelated skills of hypothesizing, critical thinking and problem solving. (18:33)

The teaching strategies of SCIS units are based on the theory that changes occur because objects interact and those interactions between physical objects result in a change. It is believed that when the child is allowed to interact with the environment in a constructive way, he will benefit. Sample units are "Scope and Sequence of Material Objects" in which the main objective is the familiarization of material objects; "Scope and Sequence of Systems" which stresses the seeking of regular pattern of behavior in a natural phenomenon; "Scope and Sequence of Subsystems" which enables the study of details or subconcepts; "Scope and Sequence of Relativity" which concerns matters of relative positions of objects, and properties of objects as they are related to one another. (18:34)

The SCIS combines content, process and attitude. In the course of diverse acquisition of knowledge through investigations, students engage in the processes of observing, measuring, interpreting data, predicting and problem solving. The understanding of science concepts is called scientific literacy and is identified as the principle objective of SCIS. (18:34)

The University of California Elementary School Science Program

In 1962 The University of California Research Center at Berkeley, California served as an experimental laboratory to explore into all the disciplines of science to determine what content should be taught and to seek the efficient method of presentation which would be consistent with the methods of scientists. Researchers developed units on human physiology, zoology, chemistry, physics, entomology, paleontology, genetics and ecology. Initially, the actual teaching of these units to children in the classrooms was conducted by curriculum developers, and later, taught by carefully screened teachers in order to obtain valid evaluation of results they had hoped to achieve. (29:58)

Particular emphasis in each of the science topics was devoted to the questions children asked about science and natural phenomenon, and to the ways of finding answers to the questions posed. The rationale of this instructional approach, of the child seeking the knowledge, and of devising methods to discover answers, seemed consistent with educational psychology and scientific inquiry methods. (29:58)

A typical lesson of the University of California _Elementary School Science Program_ (ESSP) is a unit on "Animal Coloration." This lesson follows a series of topics

to develop ideas about camouflage through matching and blending of color and shading of colors. The lesson begins with the study of the coloration of a tiger, a thorough analysis of intersecting pattern which will lead the children to experiment with their ability to produce tiger-like designs. The lesson emphasizes that animal coloration neither serves to conceal nor to advertise. Hypothesis and inferences from children are encouraged. Freedom of constructing their own experimental design and conducting the experiment to test hypothesis are recommended for highly motivated classes. (29:59)

Instructions for the teacher are adequately fortified with suggestions for proper kind of guidance to spare the children the disappointment of many failures. If proper perspective is given to the analysis of failures, the positive attitude of benefiting from an experience could be achieved. (29:59)

The speed and divisions of units are arbitrary since it is contingent upon the class developing its own design and construction of the experiment and performing the experiment themselves. The ESSP teaching materials are mostly for teacher use which are contained in the Teacher's Guide. In it are found the objectives, background planning, teaching approach, and specific instructions for using materials with children.

The children's materials consist of supplementary readings, work sheets for recording observations, and data sheet. Very little in the way of specialized material is required to perform investigations. (29:59)

Elementary Science Study

The Elementary Science Study was funded and conducted by The Educational Development Center, Incorporated, in Newton, Massachusetts. The philosophy of ESS is based on the importance of early elementary years as periods for exploration, a time to examine relationships between man and his physical world. Exploration with various materials that provide interesting and enriching experience require an abundance of activities which this study incorporates. (18:31) Children are allowed freedom to work, given time for unguided activities and encouraged to pursue different interests and to actively engage in investigations which interest them. Learning occurs when children are given the opportunity "to mess about in science" as Dawkins describes the experience. (18:29)

ESS provides the teacher with a wide range of science materials from which he can select to provide children with various learning experiences. The units carry such fascinating titles as: "Attitude Games and Problems," "Behavior of Mealworms," "Bones," "Eggs and Tadpoles," "Light and

Shadow," "Mystery Powder," "Peas," "Particles" and others. (18:29) The program also provides a Teacher's Guide, student booklet, work sheets, kits for assembly of materials and problem cards.

A brief description of a sample unit entitled, "Drops, Streams and Containers" for grades 3-4 is an investigation of liquids. Children examine flow of liquids, drop formation, properties of water and other liquids, using a variety of containers, surfaces and tubes. This type of investigation requires objects with holes in them, caps with holes, medicine droppers, medicine caps, tubes, paper towels, wax paper and cloth. (18:30)

A unit on "Optics" for grades 5-8 provides opportunity to examine many interesting aspects of light. Activities are divided into three sections; in the first part, the aspects of reflection and shadows are investigated; in the second, the study is continued with colored lights, working with colored beams to create a variety of mixed lighting effects. The third part of the unit is concerned with refraction of white and colored light by liquids. Necessary instructional suggestions and equipment are adequately provided for in each unit. (18:30)

The important free unstructured periods of explorations that ESS stresses as an initial motivation is incorporated in the introduction of each unit. (29:76) The

theory being that without an unstructured time for activity, motivation is reduced, and that children are limited by a too confining organization.

The Inquiry Development Plan

The concept of inquiry development is based on research conducted by Richard Suchman and his workers at the University of Illinois. In a survey of other programs developed on the inquiry pattern, he found several weaknesses. Some of the objections he raised were that the children asked few questions about physical events and that these questions that were asked seldom led to useful information; that children displayed limited ability to ask questions of general theory. Questions asked were limited to those of isolated facts. Also Suchman believed that children lacked adequate knowledge from which to hypothesize or theorize. These deficiencies, he felt, were due to narrow, oversimplified construction of concepts; limited experience in successful self-directed investigation which leads to decreased self-confidence in students self perception and resulted in overdependence on texts, teachers or parents for answers which they accepted without question. (29:80)

The <u>Inquiry Development Program</u> (IDP) developed objectives to foster skills of seeking information and data processing, along with concepts of logic, such as cause and

effect; to teach children an approach to learning upon which they might build concepts through the analysis of concrete episodes and identification of relationships that exist among variables; to provide the student the opportunity to experience the excitement inherent in independent research and the rewards of discovering new knowledge. (17:35)

Suchman believes that a successful inquiry development program is dependent upon four teaching procedures. A filmed demonstration of some physical event, a "problem episode" is presented to the children. For example, a baseball player is catching and throwing a ball that appears to curve from left and out to the right. Children are asked for theories to account for some of the observations made in the film. After several hunches or guesses have been stated, the next step in the stage is called the <u>response environment</u>. The children are encouraged to ask "yes" or "no" questions around the framework of the episode. This is followed by a period of refinement of theories where more pertinent questions are formulated by the students. The information is not preconstructed but formulated and determined by the child's informational needs. (29:81)

The third phase focuses on the processes of inquiry. A tape recording of the question period is played back for analysis of types of questions asked and kinds of information produced. An analysis of the frivolous and the

profitable questions, an awareness of inferences, the importance of analyzing the problems before posing questions, the value of establishing possible relationship between various elements and of ideas about casuality are some of the benefits that may result. Following this analysis of the process of inquiry, children are given <u>guided practice</u> in applying what they learn in order to gather more data in the hope of arriving at some meaningful conclusion. (29:81)

Instructional materials consist of 8 mm film loops, in series of concrete science events without comment or analysis. These are not teaching films, but are to be used merely for introducing the concepts to children, to present a problem, to challenge pupil knowledge and to raise questions in their minds. (29:81)

Two books are available for children, <u>The Idea Book</u> which suggests ways to organize data and to attack a problem; and <u>The Resource Book</u> which provides background information on the history and practical uses of the concepts related to the inquiry problem. <u>Student Experimental Kits</u> are available also to help children seek data through investigating their ideas.

A <u>Teacher's Guide</u> and <u>Teacher Demonstration Kit</u> are included for some problem situation. For the teacher, a long-playing record of a class session demonstrating the

inquiry technique development may be obtained if desired.

To summarize, the IDP is centered around physical concepts including; "The Laws of Motion," "Measurement," "Gravitation," "Heat," "Air Pressure," "Momentum," and "Energy." (29:81)

Minnesota Mathematics and Science Teaching Program (MINNEMAST)

MINNEMAST is a program which incorporates mathematics and science in the context of creative learning processes. While recognizing that each discipline is an entity in itself, the program takes advantage of the relationship between two subjects and uses the curricular integration as a means to improve education. This program was conceived during the summer of 1964 at the MINNEMAST Conference held at the University of Minnesota and sponsored by the National Science Foundation. It is an effort to lay the groundwork for the co-ordinated science and mathematics program from kindergarten through the ninth grades. (18:31)

The emphasis of the science program is placed upon activities of the scientist--what he does, how he thinks, how his problems are approached, and how they are solved. Its objectives are not the teaching of the "scientific method" in the traditional way. The program instead stresses

the operations of science. For convenience, this program only lists them as "Observation," "Measurement," "Experimentation," "Description," "Generalization," and "Deduction."

The success of the program is dependent upon the manner in which these operations of science are interwoven and interrelated into the framework of each sequential unit. The curricular organization is arranged in a spiral with the first cycle beginning in kindergarten and extending through the second grade with successive segments of the spiral built upon previous topics recurring at two or three year intervals. (29:88)

At the kindergarten level, the objectives are to instill in the child lifelong interests in thinking and in learning by attempting to build-up the child's natural curiosity, to encourage him to question observations, to seek new interests, and to broaden his experiences. The kindergarten child is asked to collect objects and sort them into different sets which focuses his attention on the properties of objects. A description of them is made in terms of color, size, shape, and other properties. This exercise helps to reinforce the mathematics concepts of grouping objects into sets. (18:32)

The co-ordinated K-3 curriculum places special emphasis on actual handling of materials by the children which leads to the fundamental understanding of concepts through

firsthand information rather than by acquiring knowledge through rote memorization.

Some instructional units stress understanding of particular operations or procedures of science to show how it may be applied to many different situations; for example, skills derived from such units as measuring or observation can be combined to the attainment of integrated or advanced skills. Another type of unit is the application of basic skills in limited context, such as measuring time or observing motion. Some units include a study of symmetrics, of changing and unchanging properties of a substance, and others combine several operations to study single science topics. (29:88)

A sample lesson from a unit in the second-grade program begins with a review of some earlier activity on weight, such as observations and comparisons of certain properties. Then length is emphasized as a basis for measurement and weight is introduced as another means by which objects can be measured, compared and ordered.

In the Teacher Commentary objectives and introductions to each unit are specified, and procedures are given for activities which are sometimes "take-home" lesson sheets on the specific learning activity. On the unit of weight, for example, Activity A would consist of a data sheet relating to "greater weights" and "less weights" wherein the

inequality of weights are discussed. Activity B consists of actually testing the hypothesis with seesaw pulleys or arm balances. Activity C records results of the exercise in which weights were compared. This is followed by a children's story to be read entitled, "About King Snooky and the Problem of Weight." (29:91)

MINNEMAST attempts to lead the children to discover the intrinsic rewards of learning, of working with classmates, and to enjoy participating in the process of experimenting, predicting and discovering answers to questions. (29:95)

Conceptually Oriented Program in Elementary Science (COPES)

Conceptually Oriented Program in Elementary Science is a kindergarten through sixth grade science curriculum organized in a way that will offer to the young people in the most efficient manner, understanding, and appreciation of science and scientific principles. The program, developed under the sponsorship of New York University and supported by the United States Office of Education under the direction of Morris J. Thomas, has as its ultimate goal a "scientific literacy" based upon content selected from "great ideas" or the conceptual scheme of science. The purpose is to test the effectiveness using major conceptual schemes of science

as underlying principles for the program.

The concepts are organized in a spiral hierarchy which both scientifically and pedagogically sound. The K-2 segments of the curriculum comprise those manipulative and conceptual skills which lay the foundation for sophisticated skills required in grade three.

The five conceptual schemas selected for this program are "The Structural Unit of the Universe," "Interaction and Change," "Conservation of Energy," "Degradation of Energy," "The Structural View of Matter." The conceptual scheme of science relegates bits of facts and experiences into a meaningful and coherent form. It orders and organizes the vast accumulation of scientific knowledge into broad concepts. Relationships of seemingly isolated facts are then easily demonstrated as subconcepts. (18:28)

The curriculum developers also recognize the need of process skills of analyzing, classifying, measuring, communicating, experimenting, interpreting, mathematical reasoning, and observing and predicting. The COPES curriculum involves children in various methods of investigation, but the primary objective is the understanding of the major concepts of science. (18:28)

Instructional materials include kits of laboratory equipment, a Teacher's Guide which is detailed and comprehensive in outlining the philosophy of the conceptual scheme

approach, the rationale of each sequential unit, the appropriate teaching questions to ask for discussion, and the explanation of the interrelationships of the various subconcepts as they fit into the framework of the major conceptual scheme. (18:28)

A plan of evaluation is devised for the purpose of aiding in the further improvement and expansion of the COPES program. The measurement of student growth is the extent of understanding acquired from concepts as obtained from individual and group achievement tests. (18:29)

Science--A Process Approach

In 1961, a feasibility study sponsored by The American Association for the Advancement of Science with the financial support of the National Science Foundation brought scientists, school administrators and teachers together under the direction of John R. Mayer, to consider the possibility of the preparation of science instructional materials for use in the elementary and secondary schools. The Association appointed a Commission on Science Education which met at Cornell University at Ithaca, New York and later at the University of Wisconsin, at Madison and made recommendations that the Commission sponsor the development of instructional materials beginning at the kindergarten level. These materials were to stress the processes of science. In the summer of 1963,

an eight-week writing session composed of thirty-five scientists, elementary teachers and child psychologists met at Stanford University, and using a statement of purpose and objectives as compiled by a panel of science educators and scientists, initiated the construction of a new science curriculum. The group worked closely with the School Mathematics Study Groups on the preparation of mathematics exercises for the science units. (48:413)

In 1963-4, the first experimental edition consisting of about 100 exercises was field tested in pilot centers by 106 tryout teachers involving approximately 3000 students. The teachers submitted feedback forms after each exercise had been taught. Using this information, again in the following summer of 1965 at Stanford University, scientists and teachers began to revise materials and wrote additional exercises. The group published the Second Experimental Edition with exercises from Parts One through Six.

Each successive summer of revision, rewriting, addition and deletions improved the curriculum as evidenced by the information provided by the feedback forms returned from the tryout schools. The many school systems which volunteered to assist the Commission in obtaining results and effects of teaching the new science program provided guidelines and direction for the writers. (48:416)

Science--A Process Approach shares certain purposes

and characteristics with other new science curricula. For example, a paper prepared by Robert Gagné has strongly influenced the work of the conference. Gagné, whose research led to the rationale for the development of the process approach, defined the various stages of child development to which he feels curriculum developers should gear their learning skills. He shares the beliefs of Jerome Bruner that the levels of scientific competence are attainable by small children if taught in an intellectually honest form, that children be introduced to the basic skills early in the study of scientific discipline, and that the opportunity to practice the skills preface the acquisition of factual information. This research has served as a guide to curriculum developers. (10:21)

The statement of purpose and objectives prepared by William Kessen of Yale University defines further the attitude of the American Association for the Advancement of Science Commission towards science education:

> Science is best taught as a procedure of enquiry . . . . Science is a fundamental instrument for exploring whatever may be tested by observation and experiment. Science is more than a body of facts, a collection of principles, and a set of machines for measurement. It is no pedagogical feat to teach a child the facts of science and technology; it is a pedagogical triumph to teach him these facts in their relation to the procedures of scientific enquiry. The procedure of scientific enquiry not as a canon of rules but as ways of finding answers can be applied without limit . . . . (48:415)

Curriculum developers have been challenged by recent psychological studies of learning indicating that high degrees of transfer and generalization are not produced on a marrowly designed task regardless of intensity of training, and that mere practice of procedure does not result in the growth of scientific concepts and logical thinking. The task of designing elementary curriculum must therefore incorporate two main conditions of learning situations as objectives: (1) the practice of the performance relevant to each newly acquired knowledge should involve a wide variety of operations and use of extensive assortments of materials; and (2) the organization of the learning situation should be such that the knowledge to be developed is attained through the individual's internal process rather than being imposed upon him from outside stimuli. (4:viii)

These basic skills underlie the practice and the understanding of science; the kind of activity in which every scientist engages without being conscious of his actions. An individual either possesses or does not possess these abilities; but each skill is something the child can learn. These skills expressed in activity words are: observing, classifying, measuring, communicating, inferring, predicting, recognizing time/space relations, recognizing number relations; and the higher integrated functions of formulating hypothesis, making operational definitions, controlling variables,

manipulating variables, experimenting, data collecting and formulating models. (48:419)

The basic skills are those believed necessary for the child to possess at as early an age as possible. Each of the skills consists of many subordinate skills and constituents which increase in complexity and in sequence towards the acquisition of a higher skill in the mental hierarchy. This sequence incorporates the body of content knowledge as well as the framework of process. (29:32)

For each of the skills, graded in degree of complexity from simple to intricate, it is assumed that the capacity of the skill is present and needs only to be developed. The sequence of developing the observation skill begins with identifying and naming colors, comparing sizes and weights, naming and distinguishing temperature differences, and identifying odors. Then, a progression through more complex skills, ultimately produces the capabilities to state a rule or a principle, to demonstrate a principle, to identify relationships of components of a system and to perceive how changes of a component affect the relationship in the system. (29:35)

In a similar manner each process in the hierarchies of skills are delineated and developed for the acquisition of a specific process skill. In the classification series, the activities begin with simple schemes of separating and

grouping common objects into living and non-living categories; substances into solids, liquids, or gas; and finally end in developing a code for classification. The child, given the opportunity to apply classification codes, perceives the relevancy of developing special codes based on the use it will be ultimately put. (29:35)

Integrated process skills are learned in the intermediate levels. The successful acquisition of integrated skills is based upon the manner and the degree basic skills have been acquired in the earlier childhood years of K-3. For example, the knowledge of number and of comparison must be acquired before children can measure; the integrated process of formulating hypothesis is built on previous experiences with the process of inferring; and before children can perform experiments, the skills of formulating hypothesis and controlling variables must be learned. (29:35)

Each process is best developed in a particular scientific context; therefore, subject matter is carefully selected. Subject matter organization is not considered for process development however, although in some of the revision there is a trend to block those lessons together which deal with a particular science content. In the levels of the integrated processes there is a wide range of important topics in physical sciences, earth sciences, life sciences and behavioral sciences. Each unit is designed

to provide maximum pupil involvement. In most lessons each child works with his own materials and equipment. (10:22)

The general pattern of the exercises may be illustrated in a unit of "Measurement." The child is charged with the task of sorting long and short dowel sticks in an exercise called "Comparing Lengths." He does this by first matching equal lengths from a mixed pile of sticks. Next, from this same assortment of sticks, he is expected to order the sets of dowels by length from the shortest to the longest. The student is also encouraged to formulate a statement that equal length can be made by matching a dowel with another or a second (standard) dowel. A variety of materials are supplied for children to perform the skill required for this activity, such as strings, straws, strips of paper, and cloth. (21:49)

Upon satisfactory completion of this activity, the child is ready for an exercise called "Linear Measurement" in which he is introduced to the task of defining standard units. A large cardboard box is displayed at one side of the room and a table at the other end; the children are asked to tell how they know whether the box would fit under the table without trying it. After some discussion, an unmarked stick is introduced (about one foot long.) Measuring the box and the table is undertaken, with discussion about how to report the measures and what to do with leftover lengths.

After arriving at some satisfactory solution of this problem, activities could be extended to include using varying lengths of sticks, names of units of measure could be invented, and others which are suggested in the guide for teachers could be used. Children are encouraged to seek their own solution for the problem. Suggestions are tried out, are either verified or rejected, and the activity is concluded by a generalizing discussion. The standard metric system then is introduced by measuring crayons, widths of rooms, and lengths of books with sticks marked off in centimeters or with meter sticks. Children learn the relationship of each unit of measure as they learn to apply the various lengths. (22:17)

Science--A Process Approach includes a Teacher's Guide for each instructional level and provides a detailed outline for each unit. The teacher is provided with statements of desired behavioral objectives, the underlying rationale, a list of materials needed, a proposal for initiating the unit, and suggested procedures for carrying out each specific topic. A built-in evaluation consisting of an individual competency measure and a group competency concludes each unit.

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EVALUATIONS OF AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE: SCIENCE--A PROCESS APPROACH

The new elementary science programs are continually undergoing evaluations and revisions. The teacher's observation of the children's classroom activities constitute a continuous evaluation of their progress. A comparative study of children who have passed through the program based on a test or measure which can judge desired behavior from undesired behavior constitutes an evaluation. A third kind of evaluation is to study what the children learn from each unit in order to correlate learning experiences and the children's behavioral changes. Evaluation is vital to curriculum makers who attempt to influence children and to administrators and teachers who make decisions regarding new programs.

The program of curriculum evaluation conducted by the American Association for the Advancement of Science of <u>Science</u>--<u>A</u> <u>Process</u> <u>Approach</u> began with the initiation of the curriculum project and was viewed as one of the principle components of the experimental activity. Within their program, the objectives of the curriculum was described in observable behavior, and measures were constructed to assess whether these objectives were achieved. The four sources of data

which were collected to substantiate their evaluation were behavior of the children exhibited after each exercise, the teacher's description of the preparation of the instruction, the progress of the children in reaching the terminal behavior of each exercise and the characteristic of the tryout teachers and centers. (2:6)

Competency Measure Tasks were designed to assess each behavior described as an objective of the exercise and to provide data on whether the child has acquired the behavior described in the objective. The goal was to produce exercises in which 90 percent of the children could successfully acquire 80 percent of the behavioral objectives. The exercises were then divided into four groups. Any exercise with about 90/90 level of acquisition was defined as Group One exercise. Group Two exercises are those in which 90 percent of the children acquire 80 percent of the stated behaviors. Group Three exercises are those competency measures showing 90 percent of the children acquiring 70 percent of the objectives. All other exercises were classified as Group Four. (2:7)

Table I shows the number of exercises at each group level for the competency measure data obtained from the third experimental edition of Science--A Process Approach published in June 1967. (2:8) Group One and Two indicate a high level of acquisition of skills. The results of Parts

Five, Six and Seven were not as encouraging and were undergoing revision.

Figure 1 displays the competency measure data for a sample of exercises from the third experimental edition of Science--A Process Approach. (2:9) Results from this 1968 study reveal seven of the ten exercises are in Group One.

Data were also collected in a study of children at the same grade level in relation to the number of years of exposure to the process approach indicated, as was expected, the greater number of years experience with the materials produced higher rates of desired behavior for most exercises. However, curiously enough, the first- and third-year students were more dramatic in their achievement than the second-year students.

In other evaluation studies conducted by David P. Butts and Anne C. Howe at the University of Texas at Austin, Research and Development Center for Teacher Education, performances of fourth and sixth grade children who had been in the program using Science--A Process Approach materials were compared with control groups. The units selected were two units on "Conservation of Volume," and "Learning Hierarchies." The fourth grade children who had had the Science--A Process Approach materials scored higher on Task I, which consisted of conservation of volume. However, no group made sizeable improvements with Task I. In Task II, "Learning

Hierarchies," posttest scores indicated all those who had received previous instructions on the process approach scored considerably higher. Performance of Task I was found to be related to age and score of Task II. The results of the investigation seemed to substantiate Piaget's theory of the presence of a progression of intellectual development of the individual. Task I, "Conservation of Volumes," contained abstract concepts, and therefore recommendation was made that the exercise be used in the upper fourth and in the fifth grade level. (30:371)

The Clayton County University of Georgia Instructional Demonstration Center, Athens, Georgia, using the Pre-Primary IA of _Science--A Process Approach_, conducted studies on three-, four-, and five-year olds. An examination of the mean test scores indicated three-year old subjects made significant gains in their study of materials as compared to those comparable groups just beginning. The achievement of very young children exposed to these materials was greater than the achievement of those who had not had experience with the materials. (6:329)

Concurrent correlation studies indicated there existed a significant positive relationship between science achievement as measured by the _Ayers Science Process Test_ and by teacher ratings. In the same study, there was a relationship between science achievement and school readiness as

measured by the Metropolitan Readiness Test. Significant positive relationship was found between science achievement and reading readiness as measured by the Reading Section of the Metropolitan Achievement Test. (6:333)

A study conducted at the University of Oklahoma in the spring of 1968, using Science Curriculum Improvement Study (SCIS) First Grade Program, compared experimental and control groups on competency required for units on "Materials" and "Organisms." Pretest and posttest scores were compared with experimental groups showing higher test scores on every aspect of the program, and it was concluded that the program does significantly enhance the first graders' ability to use simple logic and provides the type of experiences needed to initiate the movement toward the stated goal of the Education Policies Commission i.e., " . . . the development of the ability to think." (42:159)

In 1968-69, the University of Hawaii Research and Development Center investigated the effects of participation in the Science Curriculum Improvement Study program on children of Grade I level. Results indicated superior performance in certain stated objectives to those of Grade I non-participants. Six objectives were selected for examination. In respect to successful responses, the differences appear minimal from the one year exposure to the program, but they were hopeful that the cumulative effects would be measurable

by Grade VI. The study indicated that in the first-year exposure, superior laboratory behavior is all that can be expected. (1:227)

The use of 16 mm sound films as a technique of the inquiry approach emphasizes ideas and attitudes rather than facts. Learning is acquired through concentrated verbal expressions rather than through handling materials. Inquiry emphasis is on verbal behavioral responses of the students. The conclusions to hypotheses are validated by laboratory experiences. Don Herbert of the Mr. Wizard television fame and author of many books, uses this inquiry approach in presentation of ideas and challenges children with provocative questions. The television has the advantage of being readily accessible to the very young, and the "front seat viewing" surpasses most classroom demonstrations. (26:39) The educational television field holds great potential for the education of children. Programs such as NET, EXPERIMENT, and SCIENCE TWENTY are supported by the National Science Foundations. Many worthwhile projects are forthcoming in this area. (26:41)

CHAPTER III

DESCRIPTION OF THE STUDY

DESIGN FOR THE EXPERIMENT

The design for this study is closely related to the multi-group experimental method known as "the non-equivalent control group design" which involves a pretest and posttest of the experimental and control samples. By the supplementation of standard control groups to the one-group pretest-posttest design, this method seeks to minimize the main effects of such factors as history, maturation, regression, selection of samples, and instrumentation related to the internal validity of the test. (15:50)

In the graphic representation of the experimental design, the code used by Campbell and Stanley in their chapter in the <u>Handbook of Research Design on Teaching</u>, this study closely resembles Design 10, "The Pretest-Posttest Control Group Design" and takes this form:

$$O_1 \quad X \quad O_2$$
$$O_3 \quad X \quad O_4$$

The O refers to some process of observation or measurement; and the X represents exposure of the group to an experimental variable, the effects of which are to be measured. (15:51)

In this study of attitude findings, conditions under which some of these variables are controlled will be discussed. History involves the many events that may have occurred between the two measurements, in addition to the experimental variables. If differences between the two scores for the experimental group are due to the intervening historical events, then they would also show up in the results for the control group.

Studies on the experimental and the control groups were conducted simultaneously, and testings were completed at approximately the same dates. If there were differences due to the testing and maturation, these differences would equally manifest themselves in the results of both groups.

To insure against variables in instrumentation and instrument decay, the experimentors remained the same, conditions for the control of intrasession history were met, and O was achieved by student response to a fixed printed test rather than by observation or interview. (15:30)

Statistical regression is controlled in the design by the random selection of the samples and this is further substantiated by the analysis of the intelligence and achievement test scores. (See Tables II, III and IV)

Differential selection of the respondents can be ruled valid to the degree that classes were randomly selected by the teachers involved. Also the large number of students

participating in the study gives greater assurance of unbiased sampling.

Experimental mortality or differential loss of respondents remains the same with the experimental and the control groups since the schools were located in the Northeast El Paso area where the percentage of transfer student remains fairly consistent.

In September, 1970, all fifth grades of the El Paso Public Schools were being taught the conceptual approach from the textbook, Concepts of Science. (11) During the week of November 3, 1970, the Semantic Differential as pretest was administered to three fifth grade classes in each of the three schools: Stanton, Terrace Hills, and Logan Elementary Schools.

Two weeks later when the teaching materials for Science--A Process Approach became available to the school system, the program was initiated at Terrace Hill and Logan Elementary Schools and was to serve as pilot classes. The conceptual approach was continued throughout the school year at Stanton School which served as the control sample.

On May 19, 1971, towards the closing of the school year, the same Semantic Differential as a posttest was administered to the two experimental groups and to the control group. Testing at all times was conducted by the classroom science teacher.

The raw data from the testing instrument were transferred to IBM data cards, using one card per student. The ordered data were processed by an IBM 1130 Computer for the compilation of the evaluative factor, the potency factor and the activity factor as a total profile of the measure of individual attitude were ascertained.

CHARACTERISTICS OF THE SAMPLE

The sample consisted of naturally assembled collectives from similar classrooms of fifth grade students from three separate schools of the El Paso Public School System. Classes were randomly selected by the science teachers in each school to serve as a representative sampling of students in an area known as Northeast El Paso. This area consists largely of military families. The students attending Logan School were all from military families of commissioned and non-commissioned officers. At Stanton School and Terrace Hills School, approximately 70% were children of military personnel. The sample at Logan School is about 75 percent Caucasian, 20 percent Negro, and the remainder of Puerto Rican, Mexican and Oriental origin. The ethnic composition of Terrace Hills and Stanton Schools are similar to that of Logan School.

The fifth grade classes were departmentalized and traversed to the rooms in which the subjects were taught.

Science was taught for 45 minutes daily by the science teacher in a well-equipped science laboratory. The students remained as a unit except when reinforcements were recommended by the teacher who taught in that subject area. The classes were heterogenous and were not ability grouped. Their average ability and achievement scores were recorded for reference. (See Tables II, III, and IV)

MEASURING INSTRUMENT

The Semantic Differential, the testing instrument devised for determining student perception to science, was applied to this study in order to gather the necessary information for this determination. This instrument bases its reliability on the assumption that, given the sameness of human beings and the stability of learning experiences within a particular culture, meanings of most common verbal signs will be highly similar. The degree to which the students reacts to sets of successive paired antonyms and towards a concept or a stimulus measure will be indicative of their attitude about the concept being considered. (39:9)

The Semantic Differential is a combination of controlled word response associations and a series of scales arranged in a constant order. The student was provided with a concept to be differentiated on a seven-step bi-polar adjective scale and was given the task of indicating the

direction and intensity of his responses to the concept. (39:20) The descriptive polar terms have been specifically selected for Science--A Process Approach. (See Figure 2.)

The three major factors that can be extracted from student responses are the evaluative factor, identifiable by the set of bi-polar adjectives, "good-bad," "unpleasant-pleasant," "dirty-clean," and "worthless-valuable," and is indicative of value judgment. The potency factor is extracted by loading a scale with such bi-polar words as "small-large," "strong-weak," "light-heavy," and "soft-hard." The potency factor is indicative of strength. The third factor is an activity variable with some relation to physical sharpness, abruptness, action and power and is recognizable on the scale by the loading of the adjectives "fast-slow," "quiet-active," "hot-cold," and "dull-sharp." (39:20)

DESCRIPTION OF MATERIALS

The instructional materials used for this study were provided by the program, Science--A Process Approach, and developed in seven successive parts with Part A beginning in kindergarten and continuing through Part G. The program was developed in cooperation with the Commission of Education on Science Education of the American Association for the Advancement of Science, and the laboratory equipment was supplied by Xerox Corporation. The material is contained in

stacked Exercise Drawers. Each of the seven parts consists of about twenty exercises with supply items correlating with the Exercise Drawers, color-coded by the process skill the same as the booklet and labeled with the corresponding exercise letter. (3:7)

Each exercise carries a process label such as "Inferring 7." The numeral "7" indicates the exercise is the seventh exercise in which the process objective is "Inferring." A Hierarchy Chart is supplied which designates the skills the child must have had to acquire successfully before proceeding through a particular part and also indicates the skill or skills he will have acquired if successful.

Each exercise booklet for the teacher clearly defines objectives in terms of the child's performance and can be demonstrated by having the child perform tasks which can be observed by the teacher.

An activity used by samples of this study will be explained to further illustrate the organization of a teaching unit. Part E Predicting 5, Exercise f entitled "Predictions in Various Physical Systems" states the objectives the child should be able to do at the end of this exercise as:

1. NAME the decimal (tenth) and Large-number (to 1000) coordinates of points on a graph with labeled axes.

2. APPLY A RULE that the manipulated variable is plotted along the horizontal, or x-axis, and the responding variable along the vertical, or y-axis.

3. CONSTRUCT a graph, using number pairs that are decimal (tenths) and/or large-number (to 1000) from data that he collected in investigations with two related variables.

4. CONSTRUCT predictions, using a graph.

5. DEMONSTRATE tests of his predictions based on graphs. (3:1)

The Sequence Chart in the first page suggests Predicting 4, Communicating 11, Using Numbers 12 and Interpreting Data 1 as prerequisite skills for the exercise. In Predicting 5 Exercise f, Activity 1 entitled "Collecting and Sampling Data for a Simple Pendulum" involves small group activity in which the problem is defined as a survey of the number of swings a pendulum makes in a given time varies with the length of the pendulum. Devising the pendulum, manipulating and controlling variables, collecting data, recording, graphing respondents and predicting are responsibilities assigned to members of the group. Data sheets are distributed. (See Figure 3.)

Activity 2, "Using Graphs with Different Scales," involves naming points on scaled number lines and interpreting data. (See Figure 4.) Activity 3, "Predictions in Physical Systems," includes Projects A through E investigating physical systems after collecting data and plotting the data on graphs. (See Figures 5 and 6) These investigations of physical systems vary in sophistication and each group may select the project it prefers working with.

Generalizing experiences are included in each exercise to reinforce the process skills acquired and to transfer the skill to a different situation. The exercise is concluded by a Group Competency Measure to a selected group of students from each exercise. (See Figure 7) Many tasks can be scored from teacher observation of investigations by individuals and small groups of children, without using the Individual Competency Measure for Exercise f. (See Figure 8)

A competency score on each objective for each pupil is kept on an individual profile sheet provided for each student. The program suggests the recording of anecdotes and a diary of significant class events.

DESCRIPTION OF THE ANALYSIS OF DATA

The determination of whether one method is better than another necessitates comparing the central tendencies (mean) of similar samples. The design of this study was constructed to insure similarity with respect to number, grade level, social background, scholastic ability and academic achievement. In testing for significance of differences, the most frequently obtained value is the mean. The determination of the standard of difference is necessary to estimate the extent to which differences obtained from the samples would be expected to occur by chance alone. The degrees of freedom are determined by the size of the sample of the study. (41:365)

The ratio of the differences of the mean to the standard error of the differences is designated as the significance ratio. This ratio or the size of _t_ is compared to the table of _t-values_. The computed values for _t_ must fall within the level of confidence to be significant, otherwise, the differences of the mean is assumed to be due to the element of "chance." The arbitrary limits established as the levels of confidence are 5 percent and 1 percent of the normal curve.

The following formula was used for the test of significance:

$$t = \frac{M_A - M_B}{\sqrt{\frac{\sum x_A^2}{N_A - 1} - \frac{\sum x_B^2}{N_B - 1}}}$$

_t_ is the significance ratio; the value to be used to determine the probability of the obtained difference being larger by chance, by use of the tables of _t-values_ for various degrees of freedom.

M_A, M_B represent pretest and posttest scores.

N_A, N_B is the number of students in each sample.

$\sum x_A^2$, $\sum x_B^2$ are the sum of the squared deviations from the means of the scores. (41:372)

If the computed value of _t_ for a specific degree of freedom exceeds the .05 and .01 level of confidence as

obtained from a table of _t-values_, then the inference could be made that there is a significant difference between the "true" means of the two measures being compared, and the null hypothesis of differences could be rejected. However, if the computed value of _t_ lies within this level, then the null hypothesis must be accepted, and we must assume that there is no difference or change with the comparative methods under study.

CHAPTER IV

RESULTS, CONCLUSIONS AND RECOMMENDATIONS

RESULTS

The primary purpose of this study was to determine the effects on attitude of non-sequential insertion in a process approach. To this end the resulting scores were analyzed.

The results of Semantic Differential scores lead to the conclusion that there was no significance change in student attitude when transferred from the concept approach to the process approach. The evaluative factor, which is a value judgment of the process approach indicated that either method was perceived as valuable. The first null hypothesis was accepted for both the experimental and control classes. The analysis of the results of the potency factor scores indicated acceptance of the null hypothesis relating to this factor. No significant difference in the activity factor scores was found and the null hypothesis was accepted. No significant difference in the results were found to exist in either groups which might be due to different treatment of the samples.

The only exception to these results were the scores of class 5A at Logan School. For this group, there were statistically significant changes in attitude for all three

factors: evaluative, potency and activity.

The statistical analysis of the evaluative, potency and activity factors as a total profile of attitude for the experimental and control classes as shown in Tables II, III and IV.

CONCLUSIONS

Attitude by necessity is measured by the expressed opinion of the student toward the object. Values and opinions are admittedly a subjective and personal affair. A student may intentionally misrepresent or modify his real attitudes for reasons of courtesy, of uncertainty of his own opinions, or perhaps of some past experience in the classroom or in the school. The inferred subjective inclination of the student could be an attitude variable. The Semantic Differential developed as a multiple factor analysis was an attempt to decrease ~~some~~ of the discrepancies that may exist between the student's honest reaction and numerical value of each factor.

An attitude is a complex emotion and is not always wholly affixed on any single set of numerical indices. The multi-dimensional past of the student and the intricate nature of his personality, the fluctuating judgments of young people can affect the true value of an attitude. Student responses to a subject in school may reflect his entire outlook towards

school, his teacher, the interpersonal relationships between classmates, and the difficulty of the instruction materials. The pretest and posttest design was an attempt to reduce these variables.

External variables that may influence this investigation are the time of day the tests were administered, the enthusiasm of students at the time of the pretesting, and a general lessening in interest towards the end of the school year, the warmer weather during the posttesting, the physical condition of the student, and perhaps other factors which are not immediately evident. The implementation of control samples functions to show what happens to the experimental group if they had not been subjected to the experimental variable. The control samples did show a decrease in evaluative factor of the posttest scores.

Teacher enthusiams and receptiveness to a new program is often transmitted to the students. The teacher at Terrace Hills school expressed an opinion that she had thoroughly enjoyed teaching the concepts method from the textbook, especially as it was presented in the fifth grade level. She did not seem to have the same confidence in presenting materials in the process approach. This is an inferred variable.

Science--A Process Approach was built on a hierarchy of skills from which the child was expected to acquire further

skills. Not having a structured program previously and being subjected to an entirely new approach seemed to affect the students' ability to understand and to fully appreciate the purpose of the program. Although the behavioral objectives were clearly implied, they may have failed to see the relevancy of the tasks required of them as they could not get the proper perspective of their position in the whole program. The instructional material was too difficult for some as was evidenced in some activities in which the behavioral objectives were not satisfactorily performed by all the students.

The materials for Science--A Process Approach did not arrive until November 1970, and as a result all the units were not completed. The exercises taught required more time than would normally be necessary; as much time was needed to undergird the students with previous basic skills as prerequisites to the acquisition of skills for any particular exercise. Numerous concurrent basic skill requirements reduced interest to some degree.

The three classes at Logan School and the three classes at Terrace Hills School responded very favorably by voice vote their preference to the process method over the textbook method. Students at Terrace Hills expressed disappointment when informed that this program would not be offered to them in the coming year at their school.

The few students who freely exnressed their dislike for the new program gave reasons of the lack of reading materials, and "really learning science from the textbook." Studies conducted by F.S. Tanzy in 1957 revealed that science books for fourth and fifth grades were written above the student's reading level. (45:22) Students with reading difficulties did not have to overcome this hurdle as all objectives and instructions were carefully delineated by the teacher as given in the instructional procedure of each activity booklet.

There seemed to be a minimal of behavior problems, especially since this was an activity-centered approach to science. The students enjoyed the freedom of seeking solutions to problems through trial and error by using the abundance of instructional materials available with this program.

RECOMMENDATIONS

The findings of non-significant change in attitude have many implications. There are uncontrolled variables which are sometimes called "correlated biases," which have an influence of unknown proportions on the results. (40:128) Conducting a cross-survey may have eliminated these variables but time was a limiting factor in obtaining subsequent information as these samples did not exist as a unit after the

school year. Other uncontrolled variables are errors due to unreliability, misunderstanding or bias of the respondents.

An examination of the statistical analysis gives indications of a need for further studies. In subsequent studies, reasons for reduction or no gain in attitudes should be sought out. More information should be gathered when the variables suggested in this investigation could be eliminated or controlled.

Several of the science teachers interviewed expressed the opinion that Science--A Process Approach was process-oriented to the point that it neglected to teach some of the basic concepts and principles which are fundamental to the understanding and the appreciation of the beauty and order that exists in the world and in the universe. It is important that students develop skills that will enable them to maintain that beauty and that order. It would seem reasonable to construct curricula in which there is concomitant acquisition of the basic knowledge of science as well as the process skills.

The blending of the two philosophies may produce students who are cognizant of the causality of natural phenomena and are also capable of critical thinking when placed in a situation that will challenge their well-being or even their existence.

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Table I

Number of Exercises at Each Group Level for the Third Experimental Edition of Science--A Process Approach

	Parts						
Group	One	Two	Three	Four	Five	Six	Seven
1	16	20	4	13	6	8	9
2	6	6	16	7	7	6	11
3	2	0	3	4	6	10	3
4	0	0	3	2	8	4	3

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AAAS Commission on Science Education
NEWSLETTER
1515 Massachusetts Avenue, N. W.
Washington, D. C.
Vol. 3, Number 3
June 1967

Table II

SEMANTIC DIFFERENTIAL

EVALUATIVE FACTOR

Experimental Group

School	Sec.	IQ (CTMM)	GE (IOWA)	M_A	M_B	t	$p<.05$ 2.060	$p<.01$ 2.787
Logan	5A	97.8	47.9	5.9	6.7	2.6667	reject	accept
	5B	104.7	50.0	6.1	5.9	-0.74	accept	accept
	5C	103.2	49.8	6.6	6.1	-1.85	accept	accept

POTENCY FACTOR

	5A			4.5	5.3	3.37	reject	reject
	5B			4.8	4.6	-0.29	accept	accept
	5C			4.6	4.5	-0.34	accept	accept

ACTIVITY FACTOR

	5A			5.7	6.2	2.24	reject	accept
	5B			5.4	4.9	-0.24	accept	accept
	5C			5.1	5.0	-0.32	accept	accept

Table III

SEMANTIC DIFFERENTIAL

EVALUATIVE FACTOR

Experimental Group

School	Sec.	IQ (CTMM)	GE (IOWA)	M_A	M_B	t	$p < .05$ 2.060	$p < .01$ 2.787
Terrace Hills	5B	104.0	52.5	6.3	6.6	1.2	accept	accept
	5C	101.0	50.9	5.9	6.4	1.6	accept	accept
	5E	98.3	48.8	6.0	6.4	1.5	accept	accept

POTENCY FACTOR

	5B			4.3	4.9	1.4	accept	accept
	5C			5.0	4.8	-0.71	accept	accept
	5E			5.1	4.9	-0.21	accept	accept

ACTIVITY FACTOR

	5B			5.1	5.6	-0.79	accept	accept
	5C			5.0	5.9	1.62	accept	accept
	5E			5.9	5.8	-0.43	accept	accept

Table IV

SEMANTIC DIFFERENTIAL

EVALUATIVE FACTOR

Control Group

School	Sec.	IQ (CTMM)	GE (IOWA	M_A	M_B	t	$p < .05$ 2.042	$p < .01$ 2.750
Stanton	1	108.4		6.2	5.8	-1.1	accept	accept
	2	103.6		6.0	5.8	-0.55	accept	accept
	3	100.5		6.1	6.0	-0.39	accept	accept

POTENCY FACTOR

	1			4.9	4.8	-0.25	accept	accept
	2			4.5	5.2	2.80	reject	reject
	3			4.9	5.1	0.64	accept	accept

ACTIVITY FACTOR

	1			4.9	4.7	-0.16	accept	accept
	2			4.3	4.8	1.78	accept	accept
	3			4.1	4.8	6.03	reject	reject

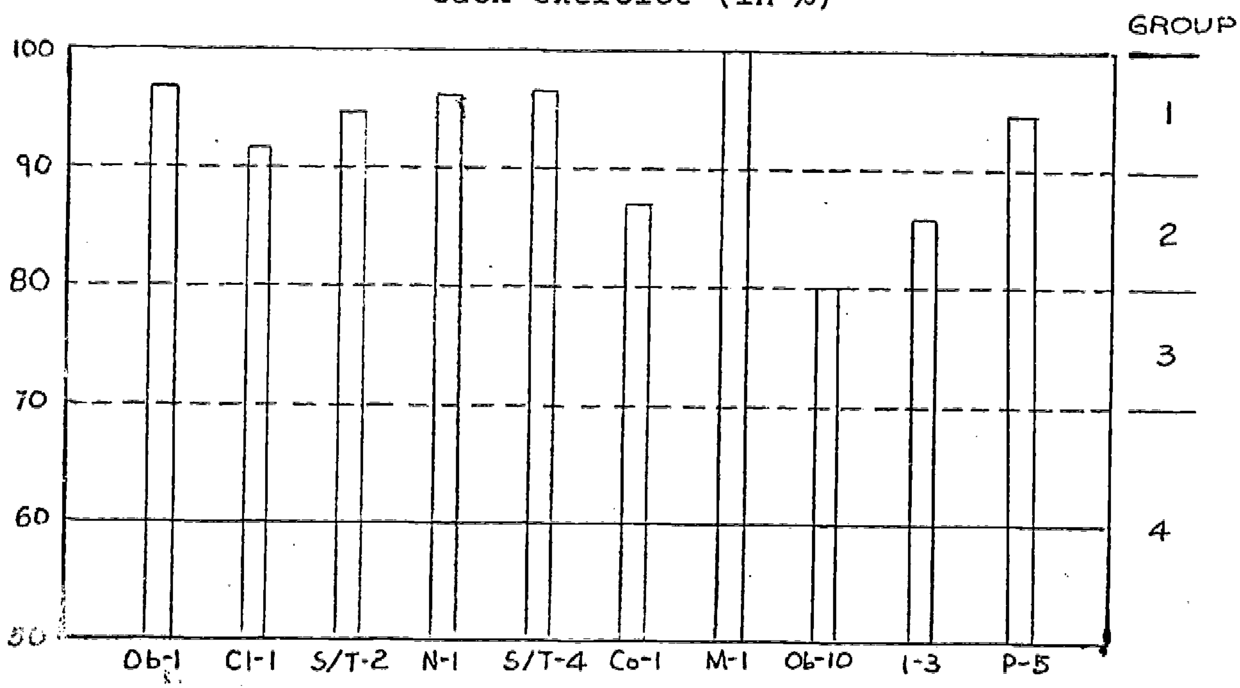
Figure 1

Graph 1

COMPETENCY MEASURE DATA FOR A SAMPLE OF EXERCISES FROM THE THIRD EXPERIMENTAL EDITION OF SCIENCE--A PROCESS APPROACH

Data from Children in all Experimental Classes

Children who acquired 90% of the specified behaviors for each exercise (in %)



Exercises

Key: C--Classifying, Co--Communicating, I--Inferring, M--Measuring, N--Using Number Relationships, Ob--Observing, P--Predicting, S/T--Using Space/Time Relationships

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June 1967
Vol. 3, No. 3

FIGURE 2

SAMPLE SEMANTIC DIFFERENTIAL FORM

1.)	Good	:___:___:___:___:___:___:___:	Bad
2.)	Small	:___:___:___:___:___:___:___:	Large
3.)	Fast	:___:___:___:___:___:___:___:	Slow
4.)	Unpleasant	:___:___:___:___:___:___:___:	Pleasant
5.)	Strong	:___:___:___:___:___:___:___:	Weak
6.)	Quiet	:___:___:___:___:___:___:___:	Active
7.)	Clean	:___:___:___:___:___:___:___:	Dirty
8.)	Light	:___:___:___:___:___:___:___:	Heavy
9.)	Hot	:___:___:___:___:___:___:___:	Cold
10.)	Worthless	:___:___:___:___:___:___:___:	Valuable
11.)	Soft	:___:___:___:___:___:___:___:	Hard
12.)	Dull	:___:___:___:___:___:___:___:	Sharp

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DATA SHEET

Exercise f

Prediction in Physical Systems

Manipulated Variable	Responding Variable

PART F

DATA SHEET

Exercise f | FIGURE 4 | Reading Number Scales 86

I. Graph A shows the distance a spring stretches when washers are attached to it. Read the graph to complete these sentences.

1. The spring stretches _____ centimeters when 5 washers are attached.
2. The spring stretches _____ centimeters when 3 washers are attached.
3. The spring stretches _____ centimeters when 2.5 washers are attached.
4. When the spring stretches 1.2 centimeters, _____ washers are attached.
5. When the spring stretches 2.4 centimeters, _____ washers are attached.
6. When the spring stretches 3.1 centimeters, _____ washers are attached.

II. Graph B shows that the distance an object falls depends on the length of time it has been falling. The time is measured from the instant the object is dropped. Read the graph to complete these sentences:

7. In 1.0 second the object will fall _____ meters.
8. In 3.0 seconds the object will fall _____ meters.
9. In 2.7 seconds the object will fall _____ meters.
10. The object will fall 60 meters in _____ seconds.
11. The object will fall 44 meters in _____ seconds.
12. The object will fall 11 meters in _____ seconds.

III. Some boys planted seeds and each day at the same time measured how tall the plants were. One of the plants grew like this:

At the end of day number	0	1	2	3	4	5	6	7
The height of the plant was	0 mm	0 mm	0 mm	2 mm	8 mm	15 mm	27 mm	40 mm

Use these measurements to complete Graph C.

FIGURE 5

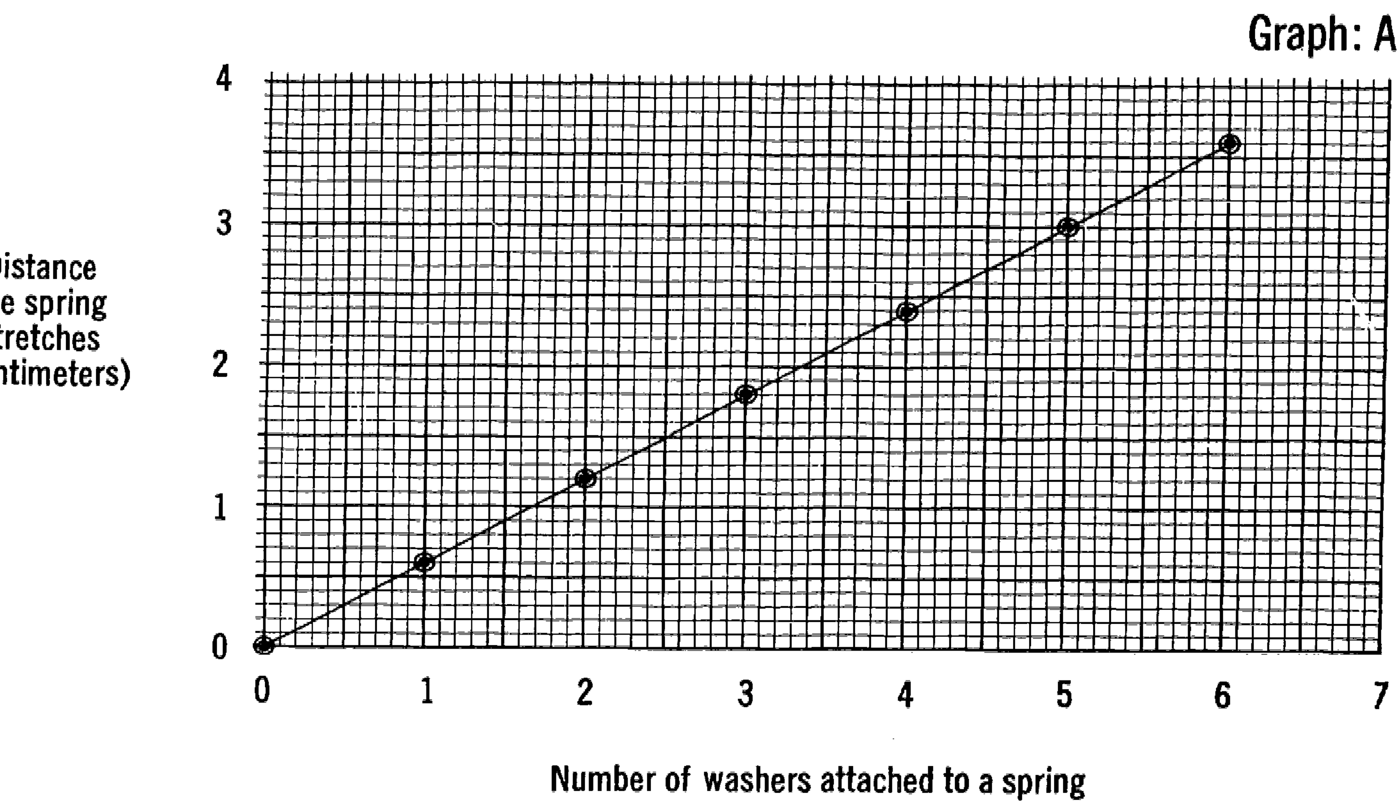
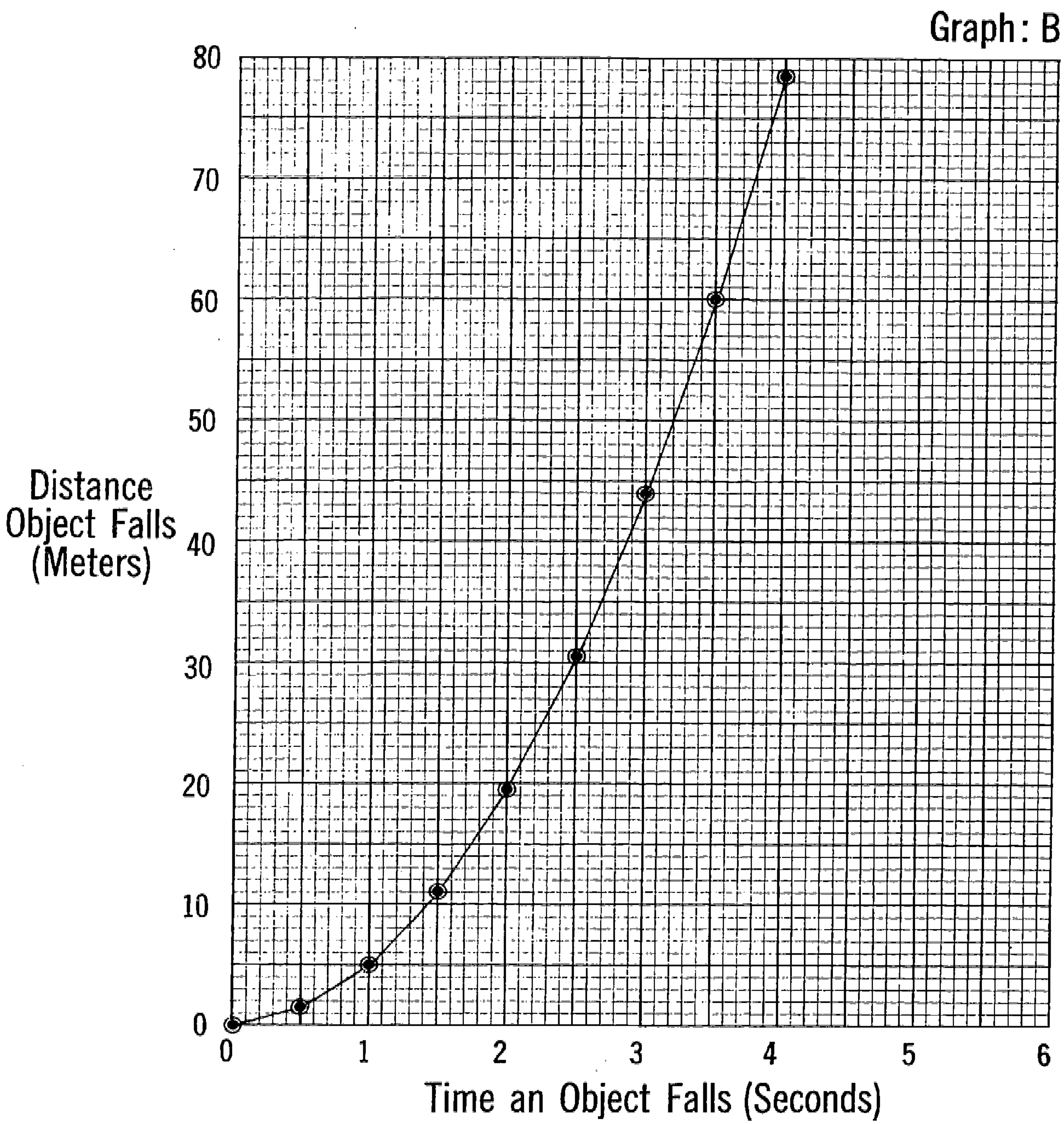
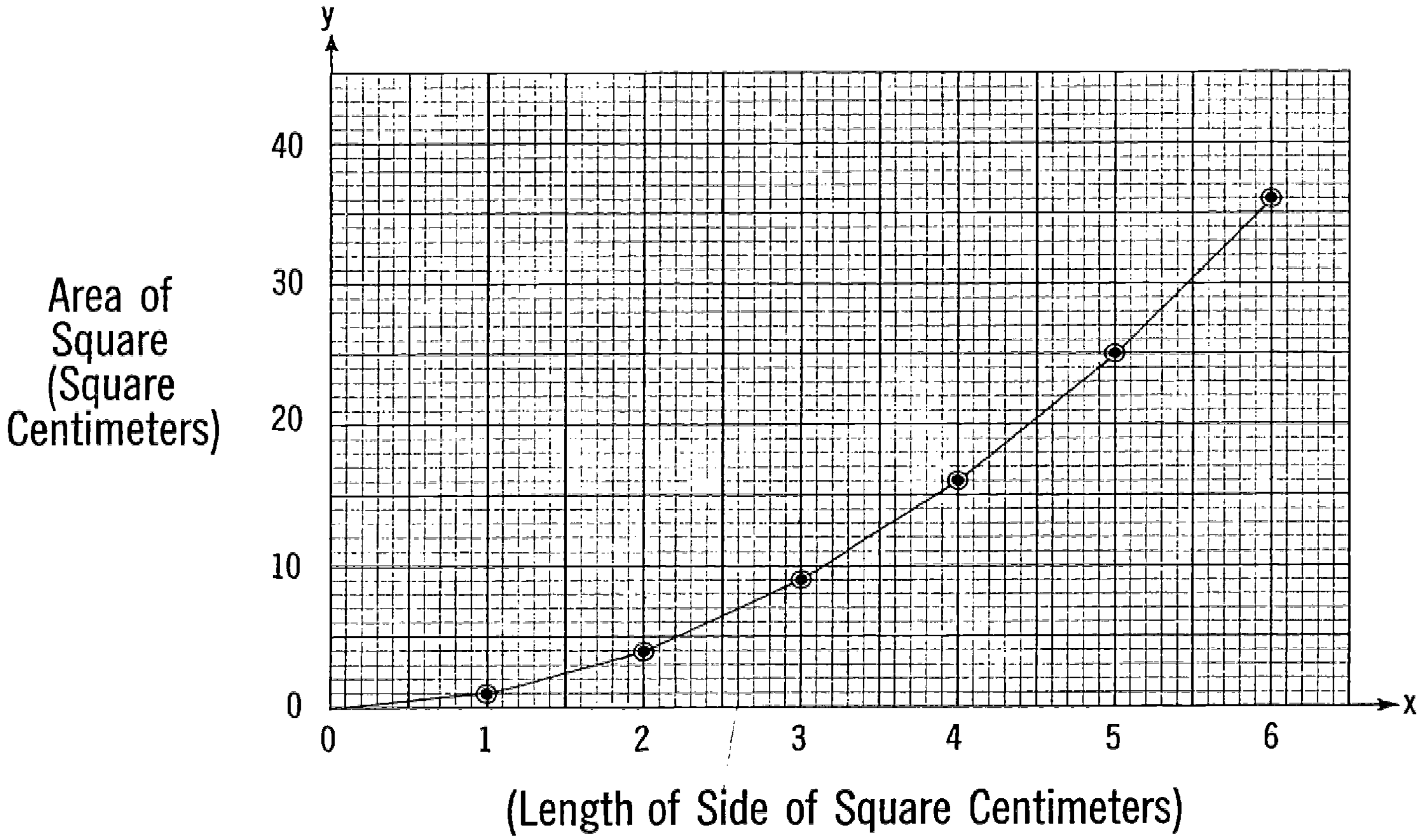

Graph: A
4
3
2
1
0
istance
e spring
retches
ntimeters)
0
1
2
3
4
5
6
7
Number of washers attached to a spring

FIGURE 6


Graph: B
Distance Object Falls (Meters)
0
10
20
30
40
50
60
70
80
0
1
2
3
4
5
6
Time an Object Falls (Seconds)

GROUP COMPETENCY MEASURE

FIGURE 7



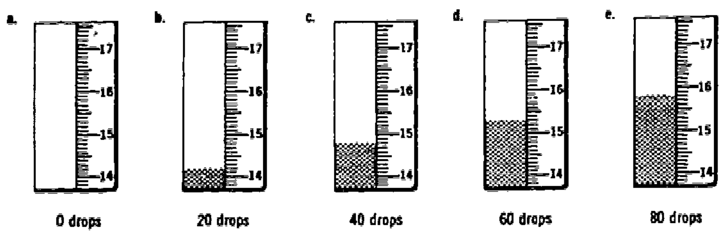
TASKS 1-3: The graph above shows how the area of a square depends on the length of the sides of the square.

1. What is the area of a square whose sides are 5 centimeters?____________________

2. What is the area of a square whose sides are 3.6 centimeters?____________________

3. If a square has an area of 21 square centimeters, what is the length of its sides?______

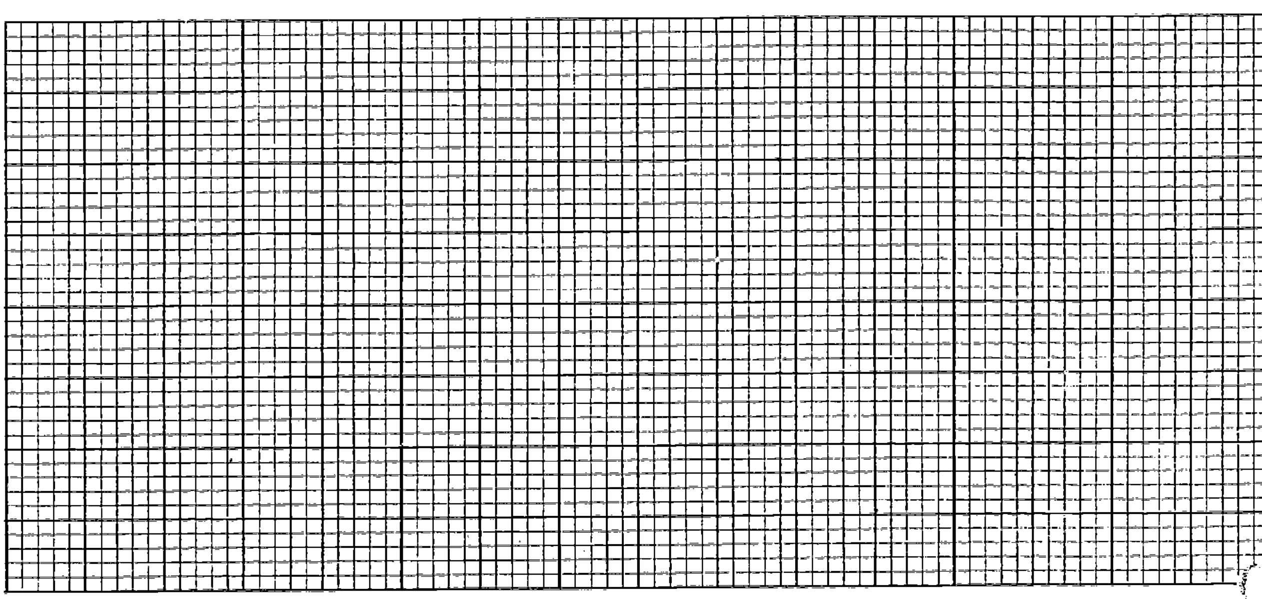
TASKS 4-7: The five pictures below show how the level of water rose in a cylinder as twenty more drops were added from a medicine dropper each time. A piece of centimeter tape was attached to the cylinder so that the water level could be measured easily.



Read the height of the water in each cylinder and record the pairs of data in the table below. The zero reading is already tabulated. Choose scales for the height and the number of drops; label the axes on the graph paper grid; and construct a graph from your data.

Manipulated Variable	Responding Variable
Number of Drops	Height of Water (Centimeters)
0	13.7
___	___
___	___
___	___
___	___

Height of Water in the Tube (Centimeters)



Number of Drops Added

TASKS 8, 9: Suppose now that you emptied and dried the cylinder and then put 35 drops of water into it. Use your graph to predict what the level of the water would be. Write your prediction here:

__________ cm.

Now write in your own words what you would do to test your prediction. ____________________

FIGURE 8

INDIVIDUAL COMPETENCY MEASURE

INDIVIDUAL COMPETENCY MEASURE

TASKS 1-3 (OBJECTIVE 1): Give the child a copy of the graph that shows how the area of a square is related to the length of the edge of the square. (See Figure 17.) Point to the graph and say, **This graph shows how the area of a square depends on the length of the side of the square. What is the area of a square whose sides are five centimeters?** Give the child time to respond. **What is the area of a square whose sides are three and six-tenths centimeters?** Give the child time to respond. **If a square has an area of twenty-one square centimeters, what is the length of its sides?**

Acceptable Behavior

For Task 1, the child says "25 square centimeters"; for Task 2, he says "13 square centimeters"; for Task 3, he says "4.6 centimeters."

TASKS 4-7 (OBJECTIVES 2-3): Give the child a medicine dropper, a container of water, a 15-milliliter cylinder with a centimeter tape or scale attached, a piece of paper on which a data table is outlined, complete with headings *(manipulated variable: number of drops; responding variable: height of water)*, and a large sheet of graph paper. Say, **When water is added to the cylinder with the medicine dropper, the water level in the tube will rise. Count the number of drops that you add and measure the height of the water. Add about twenty drops at a time. Record your measurements in the table where I have already put the zero-heading for your cylinder so that you can make a graph of the height and the number of drops.** When the child has recorded four number pairs on the table, say, **Choose a scale for the height and the number of drops, label the axes on this graph paper, and construct a graph from your measures.**

Acceptable Behavior

For Task 4, the child chooses the horizontal axis for plotting the number of drops; for Task 5, he selects a scale for the number of drops that extend from 0 to 100, or so; for Task 6, he selects a scale for the height that permits him to locate points to the nearest 0.1 centimeter; for Task 7, he correctly locates the points he has measured and joins these points with straight-line segments or a smooth curve. (The data and graph should look something like those shown in Figure 20.)

Manipulated Variable	Responding Variable
Number of Drops	Height of Water (Centimeters)
0	13.7
20	14.2
40	14.8
60	15.3
80	15.8

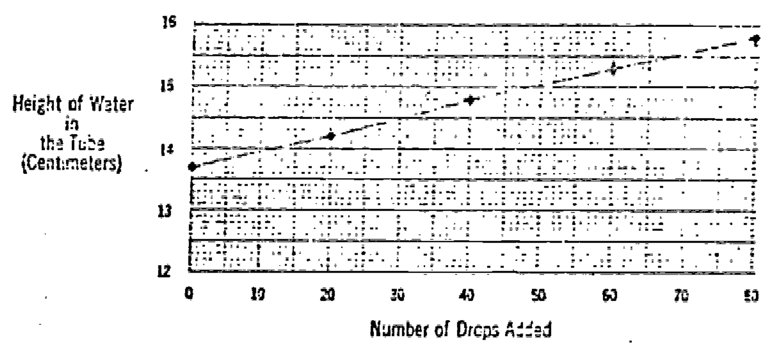


FIGURE 20

TASKS 8-9 (OBJECTIVES 4-5): Empty the tube and dry it. Say, **Suppose that thirty-five drops were added to the test tube. Use the graph you constructed to predict what the height would be.** Record the child's prediction. **Go ahead and test your prediction.**

Acceptable Behavior

For Task 8, the child correctly reads his graph to make a prediction; for Task 9, he adds 35 drops to the test tube, reads the height of the water from the scale, and compares the measurement with his prediction.

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